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Evaluation of signalment, clinical, and laboratory variables as prognostic indicators in dogs with acute abdominal syndrome

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Abstract: The aim of the study was to identify predictors of mortality and to propose a new severity scoring system in dogs with acute abdominal syndrome. A retrospective study was carried out on 58 dogs presented with acute abdominal syndrome with American Society of Anesthesiologists grades III–IV and treated surgically by exploratory laparotomy. Medical records were reviewed and information regarding dog signalment, history, clinical, and laboratory data; surgical findings; and outcome was collected. Multiple easily measurable variables were found to be mortality predictors in dogs with acute abdominal syndrome, but the most relevant were the presence of neoplastic process, organ rupture, abdominal distention, and solid organ involvement. Based on the acute abdomen scoring system, animals that received 14 points had a 50% chance of survival, with a sensitivity of 90.48%, specificity of 97.3%, and positive and negative predictive values of 95% and 94.7%, respectively, at this cut-point. According to the receiver operator curve (ROC) analysis, this scoring system classified 94.83% of the cases correctly with the area under the ROC curve (AUC) = 0.965 (P = 0.0001). The presented severity scoring system could reliably assess the severity and probability of death in dogs with acute abdomen and could be used in small animal clinical practice.

Key words: Mortality predictors, acute abdomen scoring system, dogs

1. Introduction

Acute abdominal syndrome comprises multiple diseases that are manifested with acute abdominal pain, often are life-threatening, and require immediate decision for medical or surgical treatment. Any delay could be fatal, and so the exact diagnosis may be neglected in order to save time. The approach to the animal is to discern the acute abdominal syndrome, to stabilize the vital organ functions, and to make a prompt decision for medical or surgical treatment (1).

Treatment may be extremely effortful, time-consuming, and expensive, and so the owner should be informed about the prognosis for survival as he frequently faces the dilemma of euthanasia.

In an attempt to make a more valid prognostic assessment in cases of acute abdominal syndrome, many individual predictive factors have been proposed, but most were related to definite diagnosis and not to the acute abdominal syndrome.

Further investigations showed that individual parameters should not be interpreted alone, but a multivariate analysis should be made instead (2). Based on this statement, several scoring systems with a death predictive value have been introduced in human clinical practice. So far, only the Acute Physiology and Chronic Health Evaluation II (APACHE II) and the Survival Prediction Index (SPI) have been validated in veterinary practice (3), but they are still inaccurate or not applicable to each individual case.

Our aim was to find out which of the most readily available clinical and laboratory variables could serve as prognostic indicators in dogs with acute abdominal syndrome treated surgically regardless of the underlying disease process. Based on the results, a simple scoring system for outcome prediction that stayed between the general prognostic models (e.g., APACHE II, SPI) and those for a particular disease was suggested.

2. Materials and methods

2.1. Cases

The present retrospective study included 58 dogs with acute abdominal pain referred to the Small Animal Clinic of the Faculty of Veterinary Medicine at Trakia University in Bulgaria between 2007 and 2010.

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They were divided in 2 groups: survivors and nonsurvivors. Included in the nonsurvivor group were 21 dogs who died (not euthanized) within 7 days after admission to the clinic. The remaining 37 patients were alive and discharged from the clinic after 7–21 days, thus forming the survivor group.

2.2. Examinations

All of the dogs were examined immediately after referral to the clinic and their signalment data and clinical and laboratory parameters were recorded. Radiographic or ultrasound investigations were also performed in order to make a correct diagnosis. Based on the results, a decision for surgical treatment was made in all of the cases. Disease severity evaluated by the American Society of Anesthesiologists (ASA) system showed grades III and IV. Both the surgical treatment and ASA grade III–IV together with the presence of acute abdominal pain were the inclusion criteria for dogs involved in the study.

2.3. Statistical methods

The relationships between the individual signalment, clinical and laboratory parameters, and outcomes were evaluated by means of logistic regression analysis with statistical software package MedCalc v. 10.2.0.0 (Belgium).

First, differences in the distribution of independent variables between the survivors and nonsurvivors were established. The Mann–Whitney nonparametric test was used to calculate the difference of the means of continuous parameters between the survivors and the nonsurvivors. Chi-square analysis was used for categorical variables. As mean values of vital signs expressed as continuous variables are of little clinical value, since excess mortality is only observed either above and/or below their normal ranges, continuous variables were converted into categorical variables. For example, although there were no differences in the mean body temperatures between dogs who died and those who survived, both low and high body temperature were associated with an increased chance of death. Appropriate cut-off points for hemoglobin (Hb), hematocrit (Hcr), body weight, and capillary refill time (CRT) were determined using receiver operator curve (ROC) and Youden index analysis and were presented as dichotomous variables. The rectal body temperature and respiratory rate were presented as trichotomous variables. According to the organ involved, 5 categories were formed.

The effects of single risk factors on death were further examined with logistic regression. Odds ratios (ORs), as a quantitative measurement of association between the outcome and a potential risk factors, and 95% confidence intervals (CIs) for the ORs were calculated for each parameter.

After univariate logistic regression analyses, all of the variables that showed a statistically significant relationship to the outcome were entered in a stepwise multivariate logistic regression model. The power of the model's predicted values to discriminate between positive and negative outcome was quantified by the area under the ROC curve (AUC). It is interpreted as the percentage of all possible pairs of cases in which the model assigns a higher probability to a correct case than to an incorrect case.

Finally, an acute abdominal scoring system was developed based on the results from uni- and multivariate analyses. Its predictive value was determined by the AUC. Parameters with $P < 0.05$ from the univariate analyses received a score point of 1, considering that these parameters had the least impact on survival; those with $P < 0.01$ received 2 points; and all of the parameters included in the multivariate model of death prediction received 5 points; thus, the maximal score was 35.

3. Results

Different breeds of dogs, such as the Caucasian shepherd dog, German shepherd, Bulgarian shepherd, Middle Asian shepherd, Cocker spaniel, pit bull, Staffordshire terrier, Saint Bernard, Pekingese, Chihuahua, Irish setter, West Siberian Laika, Pincher, German Spitz, Boxer, and Giant Schnauzer, were assigned to the nonsurvivor group. Fifteen of them were male and 6 were female. Their ages ranged from 3 months to 12 years (median: 8 years) and their weights varied between 710 g and 56 kg (median: 20 kg). The diagnoses of dogs that died from acute abdominal problems are described in Table 1.

The group of survivors included almost the same breeds and consisted of 21 male and 16 female dogs. The age ranged from 3 months to 13 years (median: 5 years) and the weight was between 2 kg and 58 kg (median: 27 kg). Animals from the survivor group suffered from different diseases, presented in Table 1.

Univariate analysis of all of the investigated parameters is given in Table 2. Individual predictors of death in dogs with acute abdominal syndrome are presented in Table 3.

The multiple logistic model retained the body weight, the presence of neoplastic process, a ruptured organ, and abdominal distention as statistically significant predictors of the outcome in surgically treated dogs with acute abdominal diseases (Table 4). The logistic regression model, evaluated by ROC curve analysis, from which the threshold value for the optimal sensitivity and specificity was calculated, is illustrated in the Figure. The power of the model's predictive values quantified by the AUC curve was 0.952, with a predictive mortality concordance of 93.1%.

Table 1. Diagnoses of survivors and nonsurvivors among the 58 surgically treated dogs with acute abdominal syndrome.

Diagnoses	Survivors, n = 37	Nonsurvivors, n = 21
Advanced (with rupture) spleen neoplasm		2
Advanced (with rupture) hepatic neoplasm		3
Advanced (with rupture) abdominal neoplasm		3
Traumatic spleen tearing	1	2
Traumatic gastric rupture		2
Traumatic intestinal rupture		1
Intussusceptions	7	2
Gastric dilatation volvulus	2	2
Duodenal ulcers		1
Gall-bladder rupture		1
Ruptured uterus	2	
Spleen neoplasm	2	
Kidney neoplasm	1	
Spleen torsion	1	
Prostate abscess	1	
Gastric obstruction by foreign bodies	2	
Intestinal obstruction by foreign bodies	13	
Ruptured gastric ulcers	2	
Peritonitis after surgery	3	2

Variables with a statistically significant influence on survival were included later in the design of a prognostic scoring system (Table 5). Based on the analysis results, a score of 14 had a death predictive value of 50%, while dogs with total scores below 8 and over 17 points had 100% predictive values of survival and death, respectively (Table 6). The performance of the model tested by ROC curve analysis showed that 55 out of 58 cases, or 94.83%, were correctly classified (AUC = 0.965; P = 0.0001).

4. Discussion

Our descriptive analysis results showed that the age, sex, body weight, rectal temperature, heart rate, skin elasticity, degree of pain, presence of vomiting, diarrhea, constipation, peristalsis, type of ileus, time elapsed from the beginning, previously applied treatment, and all of the laboratory variables did not differ significantly between the survivors and nonsurvivors. Body condition, the presence of neoplastic process or ruptured organ, pulse quality, respiratory rate (RR), mucous membrane color (MMC), CRT, abdominal enlargement, and solid organ involvement had a significant influence on the outcome of acute abdominal surgical disease.

Other investigators found different prognostic variables from ours because they studied a concrete disease, not the syndrome as a whole. For example, in pyometra cases, the elderly azotemic dogs having blood urea nitrogen levels of over 10.71 mmol/L and creatinine levels of over 132.6 µmol/L would more likely succumb within 3 days after surgery (4). Mackenzie et al. (5) reported that the only preoperative risk factor increasing the overall mortality rate following surgery for gastric dilatation volvulus was the presence of cardiac arrhythmias, while the factors associated positively with postoperative mortality were postoperative cardiac arrhythmias, splenectomy, or splenectomy with partial gastric resection. Galezowski et al. (6) investigated the role of C-reactive protein (CRP) as a prognostic indicator in dogs with acute abdominal syndrome and found that the initial serum CRP concentrations were not predictive of the outcome in dogs with acute abdominal syndrome, but persistent elevations for over 48–72 h were associated with poor prognosis. An investigation of patients submitted to high-risk laparotomies detected significant differences between survivors and nonsurvivors only for the parameters of age, total protein, and platelet counts, and not for packed cell volume, albumin, alkaline phosphatase, and bilirubin (7). None of these variables were considered as risk factors predicting mortality in our study.

Elderly dogs are at twice greater risk than younger dogs of developing serious perianesthetic complications, even with a low ASA grade (8). Conditions that increase

Table 2. Descriptive analyses of signalment, clinical, and laboratory variables in surviving and nonsurviving dogs with acute abdominal syndrome undergoing exploratory laparotomy, using Mann–Whitney test for the continuous parameters and chi-square test for the categorical parameters.

Parameter	Survivors		Nonsurvivors		
	n	median (range) or ratio (%)	n	median (range) or ratio (%)	P-value
Signalment					
Sex (male/female)	37	20/17 (54/46)	21	15/6 (71/29)	0.31
Age, years	37	5 (0.25–13)	21	8 (0.25–12)	0.36
Body weight, kg	37	27 (2–58)	21	20 (0.7–56)	0.213
Body condition-good/medium/poor	37	21/10/6 (57/27/16)	21	6/6/9 (29/29/42)	0.05
Clinical variables					
Rectal temperature, °C	37	38.8 (35.5–41.2)	21	38.5 (36.8–39.9)	0.30
Heart rate, min^{-1}	37	116 (70–220)	21	120 (68–160)	0.39
Pulse quality (strong/weak)	37	31/6 (84/16)	21	8/13 (38/62)	0.0011
Respiratory rate (RR), min^{-1}	37	20 (15–50)	21	36 (18–100)	0.0004
Mucous membrane color (MMC) (normal/abnormal)	37	23/14 (62/38)	21	5/16 (24/76)	0.011
Capillary refill time (CRT) (<2 s; >2 s)	37	28/9 (76/24)	21	6/15 (29/71)	0.0013
Skin elasticity (normal/decreased)	37	26/11 (70/30)	21	10/11 (48/52)	0.15
Pain (low/moderate/severe)	37	0/25/12 (0/68/32)	21	0/14/7 (0/67/33)	0.83
Enlarged abdomen (yes/no)	37	7/30 (19/81)	21	18/3 (86/14)	<0.0001
Vomiting (yes/no)	37	18/19 (49/51)	21	13/8 (62/38)	0.48
Diarrhea (yes/no)	37	5/32 (14/86)	21	3/18 (14/86)	0.75
Feces (yes/no)	37	24/13 (65/35)	21	18/3 (86/14)	0.16
Peristalsis (yes/no)	37	31/6 (84/16)	21	15/6 (71/29)	0.44
Organ involved (solid/hollow)	37	34/3 (92/8)	21	10/11 (48/52)	0.0005
Ileus (strangulating/nonstrangulating)	22	7/15 (32/68)	7	5/2 (71/29)	0.16
Time elapsed from the beginning (<24 h/>24 h)	37	7/30 (19/81)	21	5/16 (24/76)	0.92
Previously applied treatment (yes/no)	37	18/19 (49/51)	21	15/6 (71/29)	0.16
Neoplasia (yes/no)	37	2/35 (5/95)	21	9/12(43/57)	0.0001
Organ rupture (yes/no)	37	5/32 (14/86)	21	13/8(62/38)	0.0002
Laboratory variables					
Hemoglobin (Hb), g/L	21	121 (40–191)	14	102 (44–154)	0.2
Hematocrit (Hcr), %	21	35 (12–58)	14	29 (13–44)	0.12
Red blood cells, T/L	21	5.6 (2.1–8.5)	14	5.3 (1.9–6.6)	0.19
White blood cells, g/L	11	28.3 (12.9–92.2)	14	21.7 (6.2–52.0)	0.052
Lymphocytes, %	11	11 (7–20)	9	18 (3–99)	0.25
Platelets, G/L	19	309 (140–590)	13	396 (6–891)	0.66
Total protein, g/L	12	67 (47–83)	9	53 (43–81)	0.27
Albumin, g/L	12	38 (28–43)	9	32 (24–42)	0.31
Blood urea nitrogen, mmol/L	20	4.4 (2.5–32.2)	12	7.8 (2.6–26.5)	0.24
Creatinine, µmol/L	20	81 (56–421)	12	88 (38–675)	0.41
Glucose, mmol/L	12	6.1 (4.2–24.8)	4	5.0 (2.3–7.7)	0.26
Total bilirubin, µmol/L	4	29 (9–103)	5	10 (9–41)	0.16
Alanine aminotransferase, U/L	18	78 (40–264)	14	72 (23–238)	0.75
Aspartate aminotransferase, U/L	17	92 (31–468)	14	109 (45–728)	0.25

Table 3. Results of univariate logistic regression analysis showing individual predictors of death in dogs with acute abdominal syndrome (n = 58).

Variable		n	OR*	95% CI*	P-value
Signalment					
Body weight	<14 kg	37	5.67	0.28–25.115	0.022
	>14 kg	21	-		
Body condition	Good	27	-		
	Medium	16	2.10	0.54–8.18	0.285
	Poor	15	5.25	1.33–20.76	0.018
Clinical parameters					
Core body temperature	Normal	34	-		
	Increased	17	1.52	0.43–5.30	0.52
	Decreased	7	16.67	1.76–158.12	0.014
Pulse quality	Strong	39	-		
	Weak	19	8.40	2.43–29.04	0.0007
Respiratory rate (RR)	<22 min^{-1}	22	-	0.02–0.44	
	22–35 min^{-1}	18	6.36	1.12–36.08	0.036
	>35 min^{-1}	18	20.00	3.16–115.45	0.0008
Mucous membrane color (MMC)	Normal	28	0.19	0.05–0.63	0.0069
	Abnormal	30	-		
Capillary refill time	<2 s	34	-		
	>2 s	24	7.79	2.32–26.04	0.0009
Abdominal distention	No	33	-		
	Yes	25	25.71	5.90–112.21	0.00002
Organ of origin	Stomach	10	1.4	0.25–7.83	0.70
	Small intestine	19	-		
	Large intestine	9	0.8	0.12–5.21	0.82
	Liver and spleen	13	10.27	2.00–52.65	0.005
	Genitourinary	7	0	0	0.99
Neoplastic process	No	46	-		
	Yes	12	19.25	3.65–101.50	0.00048
Organ rupture	No	34	-		
	Yes	24	11.60	3.25–41.44	0.00016
Blood laboratory parameters					
Hemoglobin	<107 g/L	21	5.667	1.24–25.88	0.025
	>107 g/L	14	-		
Hematocrit	<28%	21	6.00	1.20–30.00	0.029
	>28%	14	-		

Cut-off points as established by ROC* curve analysis: for body weight: <14 kg (AUC* = 0.600); for Hb: >107 g/L (AUC = 0.629); for Hcr: >28% (AUC = 0.658); for RR: >22 min^{-1} (AUC = 0.783). *OR, odds ratio; CI, confidence interval; ROC, receiver operator curve; AUC, area under curve.

Table 4. Individual predictors of death in dogs with acute abdomen (n = 58) that entered the multivariate logistic regression model.

Variable	Coefficient	Standard error	OR (95% CI)*	P-value
Constant: –4.8118				
Body weight <14 kg	3.4002	1.2695	29.97 (1.85–484.54)	0.01663
Neoplastic process	3.2631	1.5120	26.13 (1.35–506.03)	0.03091
Ruptured organ	2.3227	1.0827	10.20 (1.22–85.19)	0.03193
Abdominal distention	3.9278	1.4199	50.80 (4.22–611.62)	0.001976

*OR, odds ratio; CI, confidence interval.

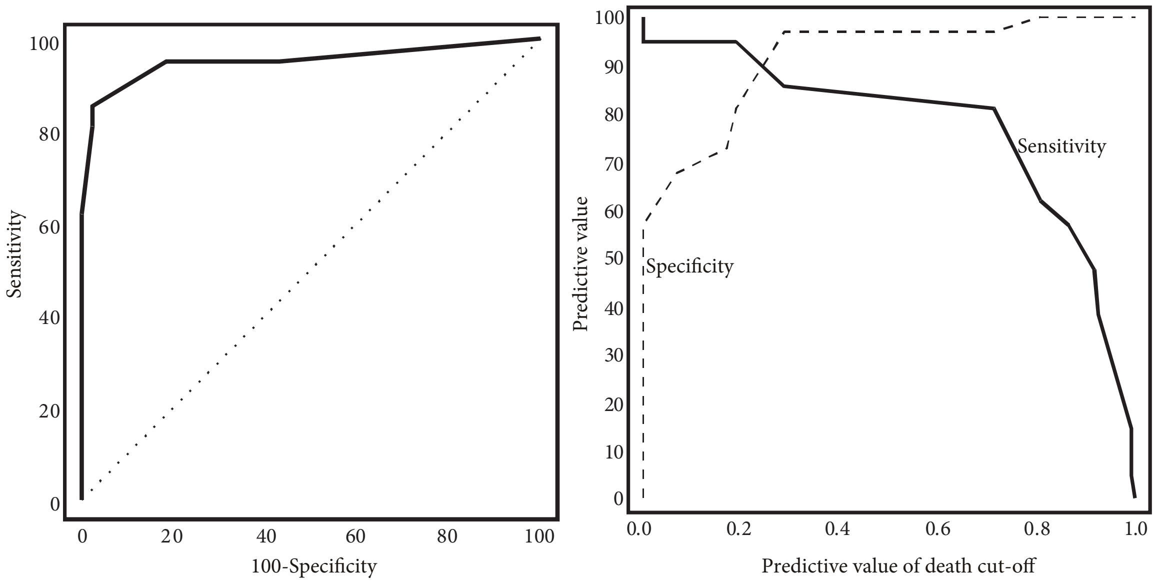

Figure. ROC of the multivariate logistic regression model for prediction of death in dogs with acute abdominal syndrome (n = 58).

the ASA grade by 1 double the anesthetic risk in elderly animals. We chose animals with equal ASA grades purposefully, since the aim was to investigate predictors of death in different disease processes with the same severity. Age did not contribute to an unfavorable outcome in the acute abdominal surgical cases included in our study.

Univariate logistic regression analysis of the signalment data demonstrated that a body weight of less than 14 kg increased the chance of death by 5.67 times (P = 0.022). The probability of a lethal outcome increased by 5.25 times (P = 0.018) if the body condition was poor, 19.25 times (P = 0.00048) if there was a neoplastic process, and 11.60 times (P = 0.00016) if there was an organ rupture. Among all of the investigated clinical and laboratory parameters, differences between the survivor and nonsurvivor groups were found with respect to Hb, Hcr, pulse quality, RR, MMC, CRT, presence of abdominal enlargement, and the organ involved. When cut-off points were established by ROC curve analysis, several individual clinical and laboratory predictors of death in dogs with acute abdomen were identified. A Hb level below 107 g/L and Hcr level below 28% increased the probability of a lethal outcome by 5.7 (P = 0.025) and 6 (P = 0.029) times, respectively. A subnormal core body temperature increased the chance of death by 16.67 times (P = 0.014), a weak pulse increased this chance by 8.4 times (P = 0.0007), and a CRT over

Table 5. Scoring system used for the prediction of death in acute abdominal diseases in dogs treated by exploratory laparotomy. Single predictive variables with P < 0.05 received 1 point, those with P < 0.01 received 2 points, and all of the parameters entering the multivariate model received 5 points.

Parameter		Points
Hematocrit <28%		1
Hemoglobin <107 g/L		1
Poor body condition		1
Body temperature below 37.5 °C		1
Respiratory rate 22–35 min^{-1}		1
	Max.	5 points
Abnormal mucous membranes		2
Respiratory rate over 35 min^{-1}		2
Capillary refill time >2 s		2
Weak pulse		2
Parenchymal organ affected		2
	Max.	10 points
Body weight <14 kg		5
Neoplastic process		5
Ruptured organ		5
Distention of abdomen		5
	Max.	20 points
Total maximum score		35 points

2 s contributed to a lethal outcome by 7.79 times (P = 0.0009). Animals with tachypnea were 6.36 times (P = 0.036) more likely to die when their RR was between 22 and 35 min^{-1} and 20 times (P = 0.0008) more likely when their RR was over 35 min^{-1}. Normal MMC could serve as a positive predictor of survival, as this parameter was related to fewer fatal outcomes: 0.19 times (P = 0.0069). One of the strongest death predictors was abdominal distention, which increased the chance of death by 25.71 times (P = 0.00002). Spleen and liver surgical problems were 10.27 times more dangerous than those of hollow and genitourinary organs (P = 0.005).

Low preoperative plasma protein and albumin concentrations were associated with septic peritonitis and death following gastrointestinal surgery in dogs with acute abdominal pain (9). The same investigators found that biliary tract surgery and preoperative septic peritonitis were risk factors of a lethal outcome, whereas the diagnosis of a foreign body was protective. We did not find a statistically significant connection between the total protein or albumin levels and mortality, but we did find a connection between solid organ involvement and organ rupture with the mortality. The total durations of anesthesia and surgery, as well as hypotension, were not significantly connected with the probability of survival after small or large intestinal surgeries but were risk factors in gastric surgeries.

Survival was not affected by the spread of the peritonitis, the cause of biliary effusion, or the duration of clinical signs before surgery in a prior study (10), similar to our results.

A retrospective study involving 19 dogs with generalized peritonitis and treated by open abdominal drainage (11) reported that a statistically significant difference between survivors and nonsurvivors had been found only with regard to alanine aminotransferase (P = 0.02) and gamma-glutamyl transpeptidase (P = 0.01), in contrast to our results, but without any connection to other studied signalment data, clinical and hematological parameters, and the duration of abdominal opening.

The substantial variety of factors connected with death presented in the above-mentioned studies and the difference between them and the prognostic indicators in our study is due to completely different designs. We wanted to unite mortality prediction factors in various surgical diseases characterized by acute abdominal pain with the same severity.

The only 4 predictors of death entered in the multivariate logistic regression model in the present work were a body weight of below 14 kg, the presence of a neoplastic process, a ruptured organ, and abdominal distention. The ROC curve analysis of the model showed that 93.1% of the cases (54 out of 58) were correctly classified.

Finally, based on the results, a simple scoring system for the prediction of the outcome was composed. According to the ROC curve analysis, this score system classified 94.83% of the cases correctly with an AUC = 0.965 (P = 0.0001). In accordance with our scoring system, a total score of <8 points predicted survival with a sensitivity of 100%, a specificity of 67.57%, and positive and negative predictive values of 63.6% and 100%, respectively. Animals that received over 17 points were classified as most likely to die (sensitivity of 57.14%, specificity of 100%, and positive and negative predictive values of 100% and 80.4%, respectively), while those having 14 points had a 50% chance of surviving (sensitivity of 90.48%, specificity of 97.3%, and positive and negative predictive values of 95% and 94.7%, respectively).

A very similar and simple scoring system is the SPI, which was introduced by King et al. (12) and serves to

Table 6. Criterion values and coordinates of the ROC. Test characteristics of the scoring system for different cut-off points in the predicted probability of death.

Criterion	Sensitivity	Specificity	+ LR*	– LR*	+ PV*	– PV*
Very low risk of death – 100% survived						
≥0	100.00	0.00	1.00		36.2	
>0	100.00	8.11	1.09	0.00	38.2	100.00
>1	100.00	16.22	1.19	0.00	40.4	100.00
>2	100.00	40.54	1.68	0.00	48.8	100.00
>3	100.00	43.24	1.76	0.00	50.0	100.00
>4	100.00	51.35	2.06	0.00	53.8	100.00
>5	100.00	56.76	2.31	0.00	56.8	100.00
>6	100.00	59.46	2.47	0.00	58.3	100.00
>7	100.00	62.16	2.64	0.00	60.0	100.00
>8	100.00	67.57	3.08	0.00	63.6	100.00
Intermediate risk of death						
>9	95.24	72.97	3.52	0.065	66.7	96.4
>10	90.48	75.68	3.72	0.13	67.9	93.3
>11	90.48	81.08	4.78	0.12	73.1	93.7
>12	90.48	86.49	6.70	0.11	79.2	94.1
>13	90.48	91.89	11.16	0.10	86.4	94.4
>14#	90.48	97.30	33.48	0.098	95.0	94.7
>15	85.71	97.30	31.71	0.15	94.7	92.3
>16	61.90	97.30	22.90	0.39	92.9	81.8
Very high risk of death – 100% dead						
>17	57.14	100.00		0.43	100.00	80.4
>20	47.62	100.00		0.52	100.00	77.1
>21	38.10	100.00		0.62	100.00	74.0
>22	28.57	100.00		0.71	100.00	71.2
>23	23.81	100.00		0.76	100.00	69.8
>26	14.29	100.00		0.86	100.00	67.3
>28	4.76	100.00		0.95	100.00	64.9
>29	0.00	100.00		1.00	100.00	63.8

*+ LR, positive likelihood ratio; – LR, negative likelihood ratio; + PV, positive predictive value; and – PV, negative predictive value.
#: 50% risk of death.

assess the disease severity of critically ill dogs. This system uses simple parameters independent of diagnosis and could be applied in any small animal practice, but the concordance with the outcome (86.3%) and AUC estimated (0.89) were lower than in our study. Moreover, the positive predictive value as well as sensitivity and specificity at a 0.5 cut-off for predicted risk were lower (77%, 69%, and 86%, respectively) than ours. This is probably due to the diversity of the pathological processes included in comparison with the narrower disease selection in our study; we investigated cases with only acute abdominal syndrome treated surgically.

In a recent study (13), the authors developed 2 accurate, validated, and user-friendly models for the stratification of disease severity to predict mortality risk in dogs admitted to an intensive care unit. They reported a 10-variable model, including creatinine, white blood cell count, albumin, oxygen saturation of the Hb, total bilirubin, mentation score, RR, age, lactate, and the presence of free fluid in a body cavity, with an AUC on the construction data set of 0.93 and on the validation data set of 0.91. The 5-variable model containing glucose, albumin, mentation score, platelet count, and lactate had lower AUCs (0.87 and 0.83, respectively) than the previous one. Both models operated independent of the primary diagnosis and had lower predictive mortality values than ours.

Another study (14) proposed an outcome prediction scoring system only for patients suffering from severe acute pancreatitis and found that the 6 variables with the strongest relationship to the hospital outcome (arterial pH, age, serum urea, mean arterial pressure, partial pressure of oxygen in the arterial blood/fraction of inspired oxygen ratio, and the total serum calcium) produced a model with a prognostic discrimination (AUC = 0.838).

The limitations of the present investigation are connected to the relatively small number of patients included in the studied cohort. Nevertheless, our model could serve as a simple tentative guide for clinicians to allocate dogs with acute abdomen treated surgically according to illness severity and to predict the outcome. Multiple easily measurable variables could serve as mortality predictive factors, but those with the highest impact with regard to the outcome were the presence of neoplastic process or organ rupture, abdominal distention, and solid organ involvement.

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